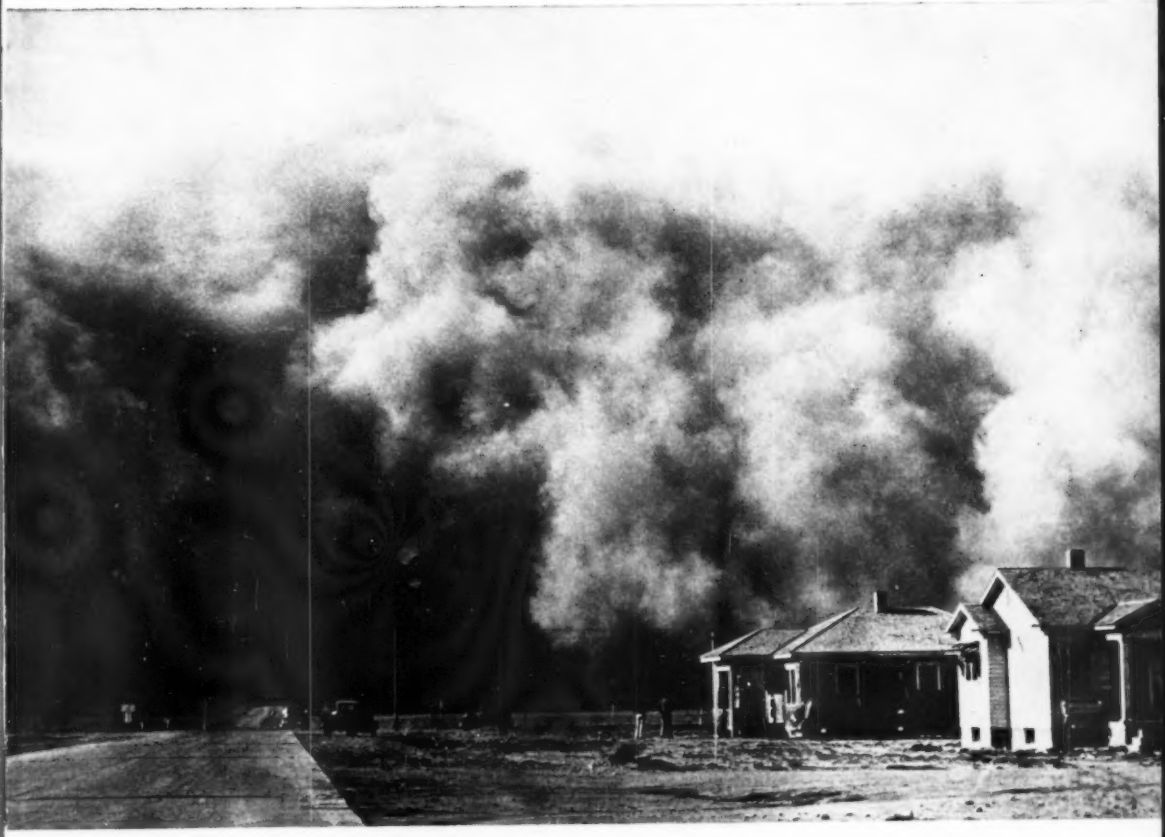
Weatherwise



Volume 6, Number 3 June 1953

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor*
HENRY W. BULKLEY, *Associate Editor*
HANS H. NEUBERGER, *Technical Editor*
ERIC SLOANE, *Art Director*

TORONTO METEOROLOGICAL CONFERENCE 1953

A JOINT MEETING OF THE ROYAL METEOROLOGICAL SOCIETY AND THE AMERICAN METEOROLOGICAL SOCIETY

TORONTO, ONTARIO, CANADA, 9 TO 15 SEPTEMBER 1953
HEADQUARTERS—315 BLOOR STREET WEST, TORONTO, ONT., CANADA

Dear Weatherwise reader: 1 May 1953

This heading tells its own story—a story of the joining together of the meteorologists of the three great English-speaking countries of the Western World to pool their knowledge in a history-making scientific meeting. We are starting now to try and get everyone who possibly can to lay his plans to attend this meeting next September.

Among the outstanding British meteorologists you will meet and hear at this conference are Sir Charles Normand, Sir David Brunt, Dr. E. T. Eady, Dr. R. M. Goody, F. H. Ludlam, Professor G. Manley, Dr. G. D. Robinson, J. S. Sawyer, Dr. R. S. Scorer, Professor P. A. Sheppard, Dr. R. C. Sutcliffe, Dr. E. T. Wormell, and possibly J. K. Bannon, Dr. G. M. B. Dobson, R. J. Murgatroyd and Professor O. G. Sutton.

They will be joined by leading meteorologists of the United States and Canada in a series of symposia on the following subjects: Ozone and the High Atmosphere, Radiation, Arctic Meteorology, General Circulation, Modern Cyclone Theory, High-level Forecasting, Climatic Change, Microclimatology, and Cloud Physics.

The meeting will be held at the time of the world-famous Canadian National Exhibition, and we are planning also a number of social and sight-seeing activities, so this would be a good occasion to bring your family. For those who must keep expenses down, a limited number of rooms will be available in a University residence hall—spartan furnishings and community conveniences, but inexpensive.

Plan now to attend!

Sincerely yours,

Horace R. Byers

President, AMS

Vol. 6, No. 3 June, 1953

CONTENTS

Drought and Dust on the Plains
—G. Frederick Warn 67

Cloud Photography Project
—Vincent Schaefer 72

The Easter Tornadoes at Bermuda
—W. A. Macky 74

Radar Tracks an Illinois Tornado 76

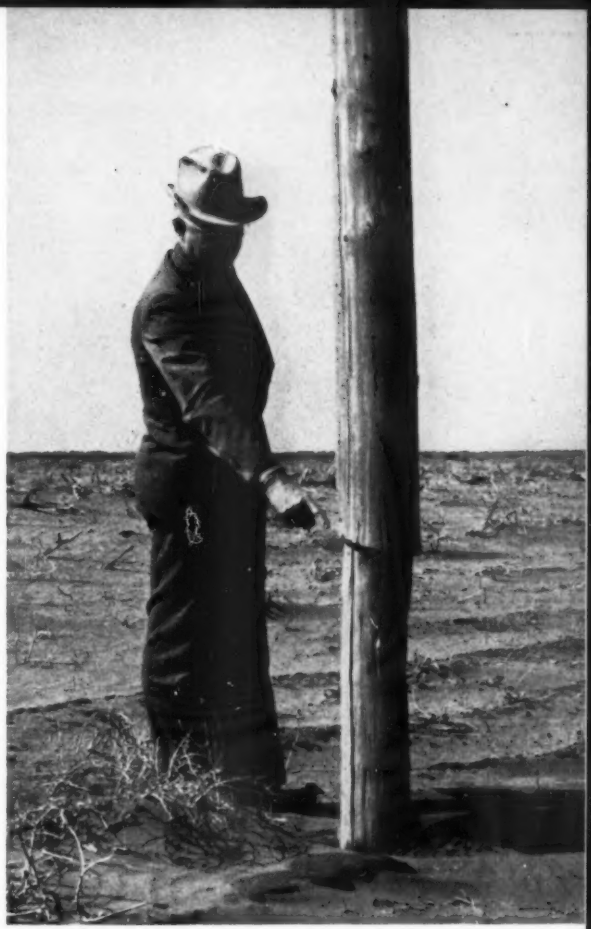
Why Did It Snow at Boston in April?
—James McGuire and Samuel Penn 78

A Late Spring Follows a Mild Winter
—David M. Ludlum 82

551.5 86

Cover: A typical dust bowl storm approaches Springfield, southeastern Colorado, 21 May 1937. Courtesy of U. S. Soil Conservation Service.

WEATHERWISE is published bimonthly for the American Meteorological Society. Office of publication, 3 Joy St., Boston 8, Mass. Subscription is $3.00 per year; add 50 cents for postage to Canada and all countries in the Pan-American Postal Union; add $1.00 for all other foreign countries. Subscription orders, claims for missing numbers, changes of address, and advertising correspondence should be addressed to the society at 3 Joy St., Boston 8, Mass. Editorial offices: Franklin Institute, Philadelphia 3, Pa.



A Texas Farmer in Dalam County points to the ground level existing when the telephone pole was installed 15 years before. About 2.5 feet of soil have blown away, and dust has sandblasted the partly-rotted, formerly underground portion of the pole. Wide World Photo.

Drought and Dust on the Plains

G. FREDERICK WARN,
Texas Technological College

WILL the dust-spawning droughts of the almost forgotten 1890's and the well remembered "dust bowl" of the 1930's return to the Great Plains in 1953–54? This question runs more and more frequently through the uneasy minds of those who remember the long droughts of the depression years when millions of acres of farm and range land were temporarily ruined in portions of eastern Colorado and New Mexico and western Nebraska, Kansas, Oklahoma, and Texas. Many recall watching the skies for rains that never fell, seeing crops shrivel and die, having pastures covered by hummocks and dunes of drifting silt and sand. Many see again the herds of gaunt cattle standing at the dry water tanks or tramping dusty ranges in search of cactus or mesquite leaves—all in a futile effort to stay alive. Many still see in the back of their minds the harried populations moving grudgingly away from the land of the "black blizzard." Some even on the Atlantic Coast can remember in 1934 their first eerie sight of the brown dust clouds, borne aloft from the windy wrath of the plains, obscuring the sun and then settling into the ocean!

But that was not the last of the dusters. Dry years through 1936 and 1937 brought equally severe results of drought and dust to parts of the plains. The Experiment Station at Goodwell, Oklahoma, for example, recorded 180 dust storms in those two years. Nearly half of these were of such magnitude as to reduce visibility to one-half mile or less.

Reappearing signs of dust disaster have come in more recent years. Great clouds of dust moved southward across the dry Dakotas in May 1945. The dreaded black blizzard returned to Kansas in February 1946. Dust clouds borne on 30 to 40 mph winds and averaging 14,000 feet in height covered the southern plains of Texas for two consecutive days in March 1950. Two months later winds of 50 to 60 mph carried dust to a maximum height of 25,000 feet across the same area and sifted it into the distant Gulf of Mexico.

At the end of 1952 the U.S. Soil Conservation Service estimated that drought and crop failure had rendered over six million acres of land in Texas and Oklahoma alone susceptible to wind erosion. Winter wheat in these areas was in poor condition through late 1952 and early 1953. An estimated 80 per cent of the winter crop land in the heart of the old dust bowl was unable to protect itself against strong winds. Dust-

making conditions were considered the most imminent since the 1930's.

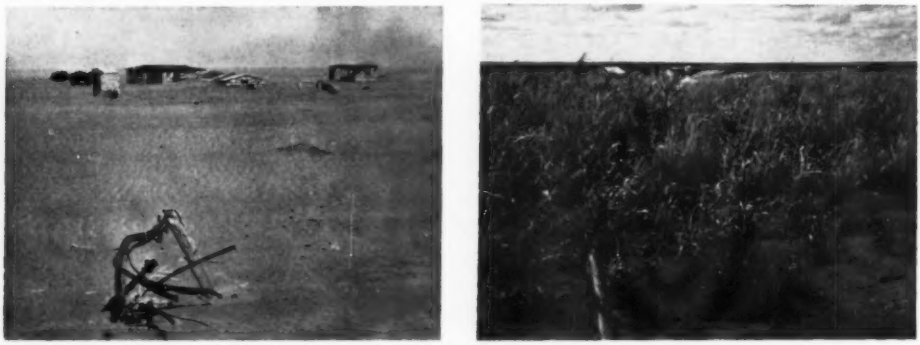
The recent drought invaded Texas early in 1951. Moisture deficiencies became serious early in 1952 and remained unrelieved in many parts of the state by the end of the year. Prolonged record heat added to the peril, with daily maxima in August hanging doggedly between 90° and 100° for as many as 30 consecutive days. October 1952 was the driest month in Texas as a whole since 1888 when the Weather Bureau began collecting records; the average for the state was 0.03 inch, only one per cent of normal. For the first time since 1914 not even a trace of moisture was recorded in the month of October at Lubbock. Parts of west Texas were so dry that the hardy, drought-resistant mesquite, symbol of the semi-arid West, was dying. The pine forests of normally-wet eastern Texas were dry, and fires ruined an estimated 262,000 acres. More than half of the state was abnormally dry and had lost, or was losing, its protective covering of vegetation, and the topsoils of unprotected fields and ranges were drifting alarmingly.

These signs were not unheeded. The Department of Agriculture, soil conservation projects, and state schools gathered data on wind erosion and experimented with preventive measures. Artificial rain-making with silver-iodide generators was tried in numerous areas with some cases of apparent success claimed. In most places the experiments were abandoned for lack of sufficient or suitable clouds for seeding. There was ample reason to believe that the dust ghost of the '30's was hovering nearby.

A brief review of the natural conditions shows that several major factors combine to produce dust storms in the Great Plains states: (1) the unequal distribution of rainfall in time and space; (2) soil type and condition; (3) high rate of evaporation; (4) sufficient wind movement.

Normal rainfall in most dust-producing areas is less than 20 inches annually, and the time and space distribution is typically erratic. The normal for the Lubbock area, for example, is 18.9 inches, but since 1911 the annual total has varied from 8.7 inches in 1917 to 40.6 inches in 1941. The dry months include November through March, and the months of strongest winds are December through May, a coincidence which helps set the stage for blowing dust.

Soil types vary considerably within the plains area, but the majority are composed of fine-grained materials of alluvial, glacial, and eolian origin. When these soils are dry, broken, and without cover, the clays, silts, and fine sands are susceptible to serious blowing in wind speeds of 20 to 30 mph. Soil analyses at Texas Technological College's Department of Geology show that 95 per cent or more of the individual grains in the soils of the Lubbock area can be moved by winds of 15 to 20 mph. Soil scientists from Kansas State College ran field tests with a portable wind tunnel in the Lubbock area in November 1952. Their tests on cotton acreage showed that 1,000 to



Two photographs of a farmstead in Baca County, southeastern Colorado. The first photo was taken in the dust bowl days of the mid-thirties. The second shows conditions several years later after the soil had been stabilized by planting a cover crop in preparation for returning the farm to active production. Courtesy of U. S. Soil Conservation Service.

1,500 pounds of soil per acre were lost to winds of 33 mph. Soil losses of several pounds up to one ton per acre were measured on fields with grain-sorghum stubble.

Relative humidity is low and evaporation is rapid in much of the plains country during late fall, winter, and early spring. Dry southwest to westerly winds frequently reduce relative humidities to lows of from 8 to 25 per cent during daytime hours. Static electricity, harmful to vegetation, shows a remarkable development in the dry winds of many cyclonic dust storms. Evaporation rates vary from 40 to 75 inches per year, the cumulative mean for the Lubbock area being 63 inches. With high evaporation rates, many of the scattered light showers of the season with low rainfall add little to the subsoil moisture. Furthermore, as quickly as the upper one-half inch of the exposed surface soil is dry, it is again susceptible to blowing. When the dry winds promote rapid surface evaporation, the remaining subsoil moisture is raised to the surface through capillary action and gradually depleted.

Many kinds of air movement are responsible for soil erosion and blowing dust: moderate daily breezes, whirlwinds and eddies, thunderstorm updrafts and downdrafts, frontal winds, cyclonic winds and, occasionally, anticyclonic winds. These winds, in order to cause blowing dust, must possess sufficient lifting power to carry surface materials to levels of continuous suspension. Lesser winds are then capable of keeping the particles suspended.

Moderate breezes are usually fitful and cause light to sporadic, localized dust movement of short duration, though often repeated. Whirlwinds are capable of lifting dust to a height of 800 feet or more, and thermal eddies may carry dust to heights from several feet to several thousand feet. Thunderstorms cause dust movement in the form of swirling updrafts, in elongated swaths beneath downdrafts, and in rolling, arc-like clouds rising from beneath the storm edges. These dust clouds are commonly less than 4,000 feet high but may rise to 8,000 feet, particularly in frontal and squall line thunderstorms. Unfortunately, many thunderstorms in the southern plains

A drought survey station at the San Dimas Experiment Forest, California, includes the following instruments: shallow blackpan evaporator, anemometer, evaporation pan, surface thermometer, rain gage, and hygrothermograph.

fail to produce sufficient rain to settle the dust that they create.

The dusters of great height and longest duration are caused by cyclonic winds, though the most spectacular ones are generated by frontal winds. Steep, rapidly moving fronts develop strong to severe turbulence in the leading edge, and frontal turbulence is very effective in churning loose surface material into dense brown clouds of dust commonly referred to as black blizzards.

Air temperature, moisture content, lapse rate, height and degree of convergence, and height and amount of cloud cover partially control the height, density, and duration of blowing dust. The colder and moister air masses tend to settle dust more rapidly after the passage of the front. Unstable lapse rates tend to develop more frequently in polar maritime air than in polar continental air. Turbulence and dust are noticed at greater heights with the unstable lapse rates. Warm, unstable Gulf air moving northward and upslope ahead of a front causes squall line formations during spring. Dust storms in squall lines are associated with types of blowing dust mentioned in connection with

thunderstorms. Sustained wind speeds in fronts over Texas vary usually from 30 to 50 mph, with peak gusts of 55 to 70 mph. The propagation rate of the frontal dust clouds varies from 20 to 50 mph. The height of the cloud is usually between 4,000 and 8,000 feet above the surface and depends mainly on the lapse rate and amount of turbulence.

Dust storms caused by general cyclonic winds tend to develop gradually, and the life of the typical cyclonic duster is limited to daylight hours. Wind speeds usually increase to 15 to 20 mph between 0800 and 1000. These winds cause low, drifting silt and sand with occasional suspension of fine dust to a height of 20 to 30 feet. As the winds increase to 20 to 25 mph, a thin yellowish haze of dust is carried upwards to several hundred feet. This thin haze is spotted locally by blowing surface dust that reaches upwards to 40 feet. Visibility ranges between 12 and 15 miles, with the latter considered as normal. By noon the effects of daytime heating are apparent, and wind speeds range up to 30 mph. These winds gradually create a thin, tan to cinnamon-hued dust haze that may rise to 3,000 feet, while blowing dust in the lower levels increases in frequency and intensity. Visibility ranges between 6 and 11 miles. By 1400 winds tend to increase to 35 mph, and a tan dust haze ranges to a maximum height between 3,000 and 8,000 feet. Visibility is from 3 to 7 miles, and sunlight becomes a blurred, bluish gray. By 1500 to 1600 winds may increase to 45 mph, when a dense brownish haze of dust begins to obscure the sky. Dust may be carried to 12,000 feet or more above the surface with visibility dropping to a range of 3/4 to 2 miles. If winds attain the unusual speeds of 50 to 55 mph, dust carries upward to 15,000 to 25,000 feet,

TABLE I

RISE AND DECLINE OF AN AVERAGE CYCLONIC TYPE DUST STORM 2 MARCH 1952

Hour (CST)	Relative humidity (per cent)	Prevailing wind direction	Average range of velocity	Average velocity (mph)	Maximum gust (mph)	Maximum 3-minute velocity	Visibility (miles)	Average elevation of dust (feet)	Maximum elevation of dust (feet)	Description (BD = blowing dust)
09 30	57	SSW 215	8–22	15	24	22	15	½	20	Lt. local sporadic BD
10 00	47	SSW 219	8–24	16	26	20	15	10	35	Same, increasing
30	41	SSW 215	10–25	16	28	23	13	300	350	Thin yellowish haze dust
11 00		SSW 216	10–32	21	33	25	10	1,000	1,200	Same, increasing
15		SSW 223	6–26	17	32	26	9	1,200	1,500	Haze increasing slowly
30	39	SSW 215	10–32	21	34	26	8	1,500	1,900	Yellowish haze
45		SSW 220	8–28	20	35	24	7½	1,800	2,200	Density increasing
12 00	36	SSW 215	10–27	20	34	27	7½	2,200	2,500	Clouds still visible
15		SSW 219	4–31	22	37	31	6½	2,500	2,800	BD increasing; gusty
30	35	SSW 215	8–31	23	36	28	6½	2,800	3,100	Sun slightly dimmed
45		SSW 220	6–28	18	32	24	5½	3,100	3,500	Sun bluish gray
13 00	33	SSW 217	10–32	24	36	28	4½	3,300	3,700	Height /density increasing
15		SSW 210	8–32	25	37	30	3½	3,500	3,900	Yellowish brown haze
30		SSW 215	12–34	23	37	31	3	3,800	4,200	Tan haze, increasing slowly
45		SSW 213	15–32	25	39	31	2½	4,300	4,700	Wind gusty; rapid dust increase
14 00	28	SSW 220	10–36	25	43	28	2	5,400	5,900	Brown haze; vis. locally ½
15		SSW 218	12–31	24	36	28	3½	6,000	6,500	Sun blurred, partly hidden
30	26	SW 225	8–31	23	36	28	4½	6,300	6,800	Brown haze, strong BD
45		SW 229	10–32	25	38	28	4	6,300	6,800	Clouds partly visible
15 00	24	SSW 216	9–34	24	39	33	4	6,300	6,800	Same, air dry
15		SW 228	8–31	22	37	27	4½	6,000	6,500	Slight decrease in haze
30	23	SW 228	12–33	24	36	30	4½	5,500	6,000	Haze thinner and lower
45		SW 228	7–38	26	41	33	4–5	5,500	6,000	Strong BD locally
16 00	24	WSW 232	8–31	23	42	29	5	5,000	5,400	Tan haze, decreasing
15		SW 221	9–30	24	39	28	5½	4,200	4,800	Dust thinning, sun bluish
30	21	SSW 219	6–32	23	38	28	5½	3,700	4,100	Yellowish tan, decreasing
45		WSW 232	12–32	24	39	30	6	3,700	4,100	Same
17 00	20	WSW 232	8–28	19	31	24	7½	3,300	3,600	Thin yellowish, drifting E
15		WSW 233	10–32	22	37	26	7½	3,300	3,600	Upper dust colloidal
30	20	SW 228	9–26	19	29	26	7½	3,300	3,600	Thicker in E & SE
45		WSW 232	4–26	17	28	24	8	3,000	3,400	Wind and dust decreasing
18 00	21	WSW 233	6–22	14	25	18	9	2,600	3,000	Dust settling; little BD
15		WSW 245	10–22	15	23	22	11	2,000	2,800	Thin yellow-gray haze
30	22	WSW 236	6–17	13	20	13	12	500	2,000	Gray colloidal haze
45		WSW 234	5–16	12	19	14	13	?	?	Dust settled except very thin colloidal haze, height unknown
Avg.	29.5	SW 222	9–30	21.3	35	27	6.4	3,538	—	
Max.	41		15–32	26.0	43	33	13.0	—	6,800	
Min.	20		6–17	13.0	20	13	2.0	—	—	

Wind speed and direction from Aerovane dual recorders, height 60 feet.
Maximum height of dust reported by aircraft pilot west of Lubbock was 7,300 feet above surface.

TABLE II

RISE AND DECLINE OF AN AVERAGE FRONTAL TYPE DUST STORM 2 MARCH 1952

Hour (CST)	Relative humidity (per cent)	Prevailing wind direction	Average range of velocity	Average velocity (mph)	Maximum gust (mph)	Maximum 3-minute velocity	Visibility (miles)	Average elevation of dust (feet)	Maximum elevation of dust (feet)	Description (BD = blowing dust)
19 15	27	WSW 263	6–10	9	11	9	13	Colloidal	Haze aloft	No BD, frontal dust cloud to W & NW approaching
25		W 270	12–21	16	24	16	10	35	35	Local BD, dust in near W
30	32	NW 312	5–26	18	28	24	5	3,800	4,400	Cold front; dust cloud edge; visibility dropping
45		NW 313	12–40	28	43	38	3	4,500	5,000	Main body dust cloud passing; turbulent wind
20 00	38	NW 310	18–38	29	40	35	5	5,000	5,500	Strong BD all quadrants; lights dim, bluish
15		NW 310	20–32	26	34	30	6	5,000	5,500	Dust haze thinner; humidity up, temp. down
30	45	WNW 308	14–34	27	39	32	8	4,300	4,900	Relatively thin haze; dust cloud moving ESE
45		WNW 307	14–38	26	39	36	9	3,800	4,200	Dust settling rapidly; vis. increasing
21 00	47	WNW 307	8–32	25	36	32	9½	2,800	3,300	Clouds increasing
15		WNW 308	14–30	22	34	25	10	2,100	2,600	Rear dust cloud passing; temp. dropping
30	50	WNW 307	14–36	25	38	32	11	1,200	1,500	Local BD to 35 feet; thin dust haze aloft
45		WNW 307	12–30	23	36	28	11	800	1,200	Very thin haze; colder, overcast, sprinkles
22 00	58	WNW 307	10–28	19	30	25	11	—	—	Dust settled; sprinkles; vis. reduced by virga
Avg.	42	WNW 309	13–34	25	37	31	7.8	3,300	—	
Max.	50		18–38	29	43	38	13	—	5,500	
Min.	32		5–26	18	24	24	3	—	—	

and visibility drops to between zero and 3/4 mile. Relative humidity may fall as low as 6 per cent. Winds above 55 mph cause more severe dust storms but, happily, are infrequent. The maximum height of dust in severe storms witnessed by the writer is 30,000 feet. Visibility during the maximum development of such storms is zero to 1/8 mile.

Cyclonic winds normally diminish by sundown and dust subsides between 1700 and 2100. The rate of dust subsidence is slower in the final stages of the storm. Following strong storms, a yellowish or grayish tinge of colloidal dust may linger aloft until noon of the following day. Since cyclonic and frontal dust storms are frequently associated, the winds, in some cases, may subside during the approach of a cold front and the dust may settle completely before frontal passage, only to be stirred up anew on the shifting frontal winds. The tables below show the development, characteristics, and decline of an average cyclonic dust storm followed by a mild cold front dust storm.

Numerous low pressure cells develop trough lines east of the Rocky Mountains that subsequently move eastward slowly. Dry winds flowing from the south, southwest, or west into the trough cause mild to severe dust storms and may last from 10 hours to several days. Trough lines that move rapidly cause equally severe storms, but blowing dust is of considerably shorter duration.

A number of factors tend to vary the patterns described above. Dust hazes or clouds which develop in dry, windy areas far removed, and then drift across with the upper winds, are less severe than when blowing dust is developed locally. Strong or turbulent winds usually have little effect on areas with grass cover or moist surface soil. Low cloud layers may restrict blowing dust to lower levels than do decks of middle or high clouds. An overcast sky tends to lower visibility without an increase in the density of blowing dust. A slow rate of surface heating may produce air movement with little lifting power and thus a minimum of dust movement. Steady winds of 25 to 40 mph occasionally produce little or no turbulence or gustiness and, consequently, little or no blowing dust.

When all of the causative factors of blowing dust are reviewed, it is apparent that drought and unprotected soil are the basic ones. And it is mainly for these two factors that realistic minds are wondering uneasily whether dust-bowl days can return to the Great Plains.

The scene at the Cold Springs Lookout, Nez Perce Forest, western Idaho, shows the author in the foreground with a time-lapse camera and Seven Devils Mountain, a cloud target, in the background.

Cloud Photography Project

VINCENT SCHAEFER, *Technical Advisor, Munitalp Foundation, Inc.*

THE sky was clear except for a scattering of fair weather cumulus over the mountains. Two climbers moved steadily toward the summit of Twin Sisters Peak in the Rockies, one carrying a loaded rucksack, the other a packboard having an instrument case lashed to its surface. The date was 18 August 1952, and by early afternoon another time-lapse motion camera was located on a mountain top, ready to record the life cycle of clouds in the vicinity of nearby Longs Peak.

This was the sixth camera outfit taken to the summit of a western mountain during the summer of 1952 as part of the Munitalp Atmospheric Research Project, a cloud survey plan which has for its ultimate goal the preparation of a comprehensive series of time-lapse motion pictures of the typical cloud forms that occur in the representative regions of the world. The effects of the local climate, terrain, nuclei concentration, moisture, temperature, and wind on the cloud structures are recorded beautifully by time-lapse photography using 16 mm. color film.

The project dates from May 1952 when, under the guidance of Mr. Vernon Crudge, executive director of the Munitalp Foundation, and the writer, it was decided to prepare 10 complete self-contained time-lapse camera outfits. These were to be compact, easy to operate, light in weight, and free of trouble. Two months later the units were ready for field operation. Each consisted of a Bell and Howell magazine-type camera with a special automatically-timed shutter control operated by a 45 volt "B" battery, a tilt head with adjustable azimuth scale tripod, exposure meter, protractor for measuring elevation, title board, and notebook. The entire equipment with twelve 50-foot magazines of 16 mm. color film fits into a fiberboard carrying case that measures $5 \times 9 \times 19$ inches and weighs slightly less than 25 pounds. With a little practice the camera may be removed from the case, mounted, and put in operation within less than three minutes.

Since the photographic program involved the operation of cloud cameras for extended periods in isolated locations, it was necessary to devise an operating procedure that would be effective and also inexpensive. Since cloud performances cannot (as yet) be

scheduled in advance, it was important that a means be found to assure a reasonable chance that a photographer would be available when suitable cloud developments occurred. From past experience the writer knew that a possible source of assistance resided in the personnel at the fire lookout stations of the forest and park services.

Enthusiastic support was offered by both groups when approached. As a result, seven tentative sites were selected for a trial program. Personnel manning the forest fire lookout stations are carefully selected: they must be self-reliant, capable, and intelligent individuals who have a liking for outdoor work and most things associated with it. In a number of instances, a husband and wife team, often college students, are employed.[1]

These young men and women, some of them never having used a camera before, were checked out personally by the writer on the type of clouds to photograph, the use of the exposure meter, setting up of the camera, and its operation. Simple instructions were left with each camera outfit.

By the middle of September nearly 4,000 feet of film had been exposed, shipped for processing, and returned to the writer for editing. Of this four-fifths mile of exposed film, less than 10 per cent was not usable. Thus the initial project was an unqualified success, thanks to the careful work of the fire observers and the excellent co-operation of the personnel of the forest and park services, from national headquarters to the local ranger district.

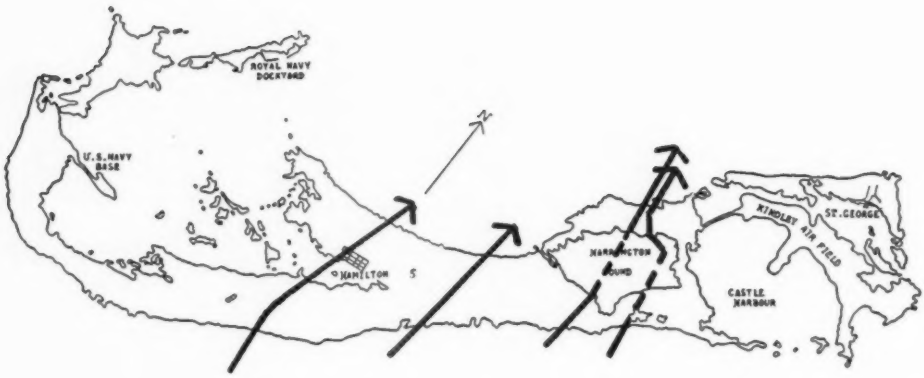
The original film was copied after rough editing, and one of the copies was presented to the group responsible for obtaining it. The original film is filed in a safe place to become part of the permanent collection of the Foundation. Work is now in progress on editing the film taken last fall and winter and preparing it in useful form. The photographic program is continuing and, as a result, a series of movies will become available for use in seminars, in teaching meteorology in schools, and for general educational purposes.

The wide variations in topography, temperature, and general climate conditions found in the United States offer nearly every type of situation one could find in any part

(*Continued on page 85*)

[1] In the period from July to September the following persons operated cloud cameras in the West: Mr. Dan K. Merrill, Gisborne Mt., Northern Idaho, Kaniksu Forest; Mr. and Mrs. William A. Brown, Hemlock Butte, Central Idaho, Clearwater Forest; Mr. Richard Jungers, Round Top, East Central Idaho, Lolo Forest; Mr. Otis W. Taylor, Cold Springs L.O., South West Idaho, Nez Pierce Forest; Mr. and Mrs. W. M. Fenner, Twin Sisters, Central Colorado, Rocky Mountain National Park; Mr. and Mrs. Charles E. Pittinger, Signal Mt., Central Wyoming, Grand Teton National Park; Mr. Glen T. Bean, Great Sand Dunes, Southern Colorado, Great Sand Dunes National Monument.

Contents and carrying case of a time-lapse motion picture outfit.



The Easter Tornadoes at Bermuda

W. A. MACKY, *Bermuda Meteorological Service*

THE central part of Bermuda was visited by at least four tornadoes between 1800 and 1830 on Easter Sunday, 5 April 1953. Moving from south to north across the narrow island, the twisters did considerable damage to property, killed one woman, and caused many injuries ranging from minor bruises to broken limbs.

The two most westerly tracks shown on the accompanying map were reasonably well defined, but there is some doubt about the others. It appears that the westernmost tornado came in from the sea about 1806, the middle two about 1815, and the easternmost about 1820. All observers state that they looked like a heavy rain squall and did not have the sharply defined boundaries of typical waterspouts. Several people reported that they could see the cloud rotating, and many felt a sudden pressure change in their ears. Heavy continuous lightning occurred in the central two but not in the others.

The westernmost whirl passed very close to the meteorological office where the anemometer recorded two gusts to 89 and 85 mph at about 1812. At this time the barograph trace fell about eight millibars and rose again immediately to a higher value than before. The record shows that the wind veered from northeast to west at the moment of the two extreme gusts.

On the weather map, a depression was located about 150 miles west of Bermuda at 1400 with a warm front approaching the island group from the southwest. Weather had been overcast with low clouds during the day, and intermittent rain fell during the afternoon. The wind from the south-southeast increased to 28 mph by 1700, and a very heavy rain fell in most parts of Bermuda about 1800, with one inch in 15 minutes being recorded at Hamilton. The surface warm front passed at this time, and apparently the tornadoes were associated with the passage.

About 90 properties were damaged, but only a few buildings were so demolished that they became uninhabitable. In most cases the damage consisted of sucking or blowing from the roofs the slates of Bermuda stone, with which all island structures are traditionally covered, leaving the supporting wooden rafters intact.

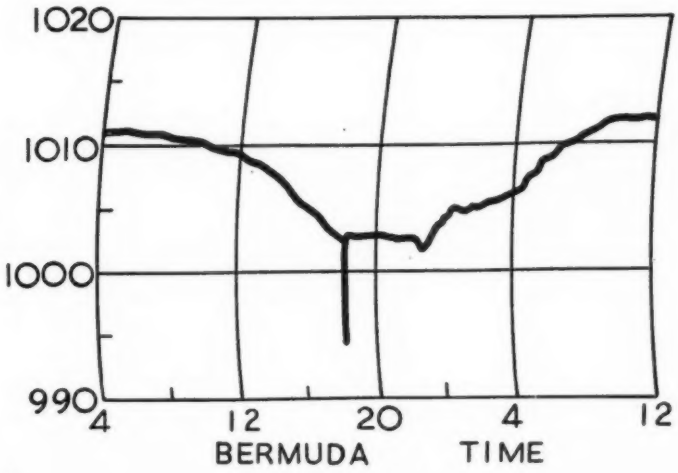
The most spectacular damage was on the south side of Harrington Sound where the tornado came down from the higher land and picked up several poultry coops containing hundreds of chickens which vanished entirely, apparently into the water. At the same time the twister lifted one parked car and another that was moving on the road, depositing them in the sea right side up about 100 feet away. Fortunately, the occupied car stayed afloat long enough for the driver to escape.

There were many instances of adjacent

The damage caused by the sucking aloft of the roof stones of a Bermuda house is illustrated in this scene of destruction.

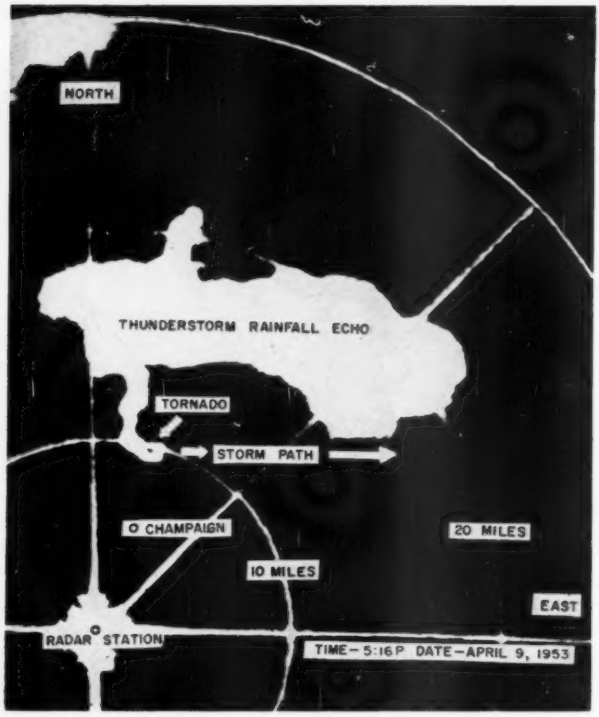
objects being carried in opposite directions and of articles of clothing being sucked through the ceiling of unroofed houses. In Hamilton a gentleman standing on his verandah saw a large beach umbrella fly past from the east. Then, perhaps 15 seconds later, the wind blew straight in from the south piling debris on his verandah, and, a few seconds later, the umbrella flew past again coming from the west.

Heavy objects were blown considerable distances, and there would probably have been a much heavier toll of life but for the facts that the day was a Sunday and that the heavy rain beforehand had driven people to take shelter indoors. The one casualty resulted when a woman left a damaged house to carry her small sister to safety and was struck by flying debris while the baby was unhurt.



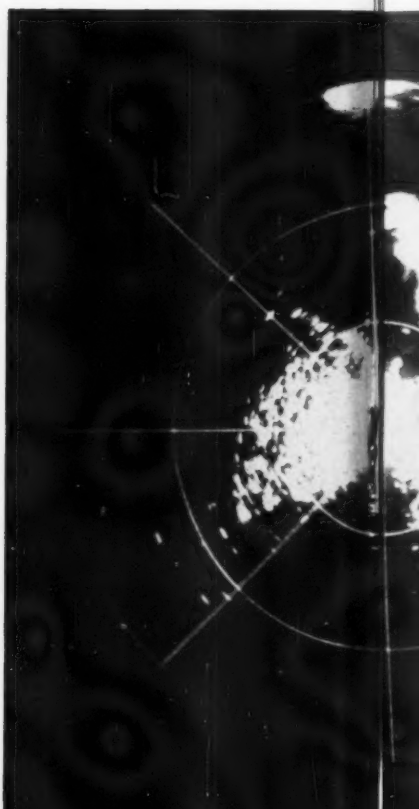
The microbarograph trace shows an immediate drop and rise of approximately eight millibars as the tornadoes passed near the meteorological office.

Radar



At 1716 a thunderstorm echo and its appendage are shown at a distance of 10 to 20 miles to the north and northeast. The curling portion of the appendage is the tornado location. The radar beams survey from the surface to about 2,000 feet in the vicinity of the tornado echo.

At 1719 the curling portion of the echo co
An eye in the tornado echo is now evident
48 mph. The tornado is located about 1



ar Tracks an Illinois Tornado

A CENTRAL Illinois tornado was recently tracked on a radar-movie camera by Glenn E. Stout and his associates at the radar meteorology station of the Illinois State Water Survey. This is believed to be the first time that a tornado has been subject to continuous radar scrutiny during its formation and major development.

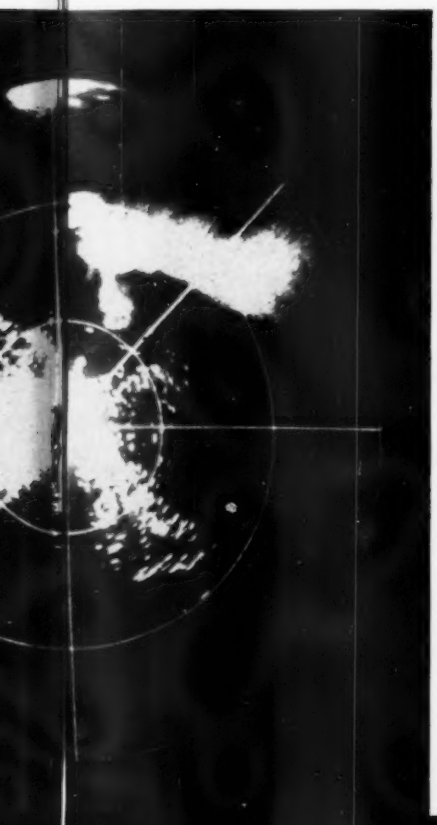
While pursuing their normal precipitation studies of a thunderstorm at 1615, 9 April 1953, some unusual radar echoes were noticed. At 1706 one of these echoes at a distance of approximately 10 miles developed a tail, which, as it moved eastward at about 48 mph, curled into a cyclonic whirlpool about 1.5 miles in diameter. The unique echoes were followed until 1900.

The significance of these echoes was realized soon afterwards on receipt of reports that a destructive tornado had followed the exact path of the radar echoes. The swath of destruction on the ground had grown from 500 feet to approximately 1.5 miles, and it appeared that a "tornado cyclone" circulation had developed around the whirl.

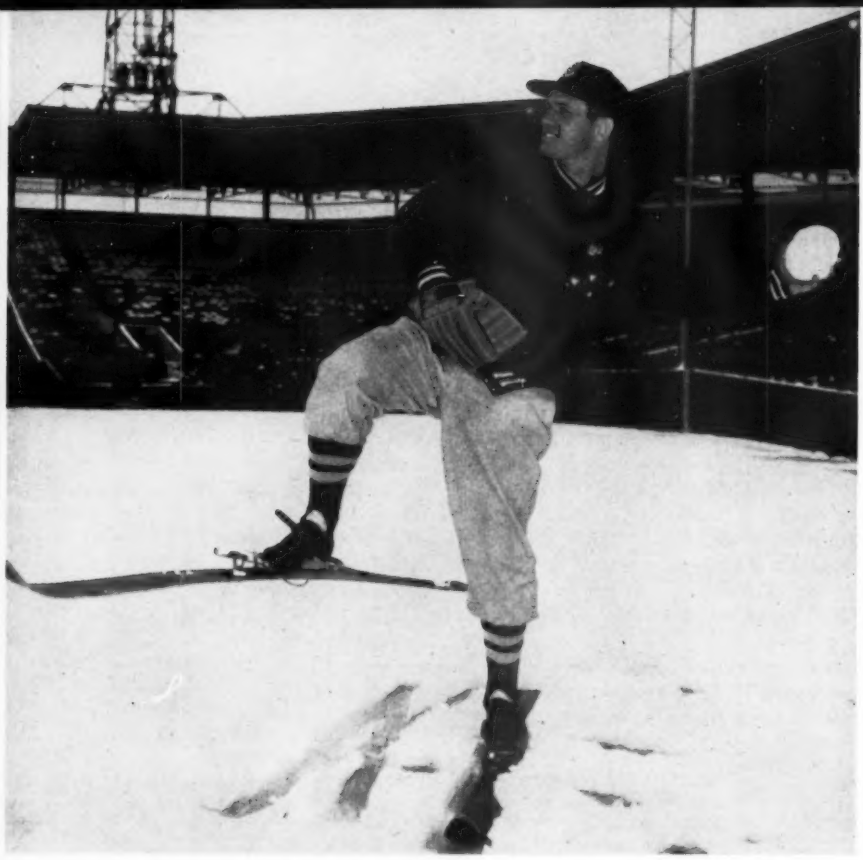
The three radar pictures below were taken at the radar site of the State Water Survey at the University of Illinois Airport, five miles south of Champaign. The circular markers on the radar scope are at 10, 20, and 30 mile intervals from the radar site. The white, irregular masses at the center of each photo are scattering of radar echoes caused by interference of buildings and obstacles in the immediate vicinity of the airport.

Mr. Stout presented his series of unusual photographs at the recent meeting of the American Meteorological Society in Washington, D. C. A full presentation and technical study of the entire series will appear in an early issue of the Bulletin of the AMS.

f the ec continues its cyclonic development. s now ident as it moves eastward at about ated about 11 miles north of the radar site.



At 1733 the tornado echo has continued to grow, the thunderstorm echo has decreased in size, and several echo bands have appeared, giving the spiral appearance. The tornado was reported to have reached its peak of destructiveness at this time.



Mel Parnell of the Red Sox pitches snowballs instead of baseballs on the scheduled opening day at Boston.

Why Did It Snow at Boston in April?

JAMES MCGUIRE AND SAMUEL PENN, *U. S. Weather Bureau, Boston*

PROPER Bostonians who retired early on the rainy evening of 13 April 1953 awoke to a surprising scene the following morning. The staid old city was blanketed by a snowstorm, officially measured as 2.2 inches at the Airport on Boston Harbor, but it ranged up to five inches in parts of the city and to eight inches in the inland suburbs.

Snow in April is no rarity in the Hub. It has occurred as late as 19 May 1945, but all late-season falls have been only traces from flurries or quickly melting snowflakes. There have been only five April occurrences since 1940, none since 1947. So the startled citizenry rubbed their eyes last 14 April, and cancelled plans to attend the opening day at Fenway Park, where the beloved Red Sox hurled snowballs instead of baseballs.

Just 20 years before, another opening day (13 April 1933) was greeted by 5.0 inches of snow, and the same date in 1918 brought a fall of 4.2 inches. Way back in 1894, 3.1 inches were measured on 12 April. Thus, the 1953 storm ranked as the fourth heaviest late-season fall—after 12 April—of the city's 82 years of official weather history.

As might be expected, search for the causes of what the local newspapers called a "freak snowstorm" involves an interesting bit of meteorological research.

Average temperatures for the winter months of 1952–53, as in the four previous winter seasons, were above normal, and April had continued the March trend of mild and very rainy weather. On the evening of 13 April it was raining (as usual!), and the mercury stood in the low forties. Snow for

Boston and vicinity seemed out of the question, though the forecast called for some in interior Massachusetts.

The surprising white shower can be best understood if the course of the four low pressure areas shown on the accompanying chart and maps are considered. The fourth of these "bad actors" at 1930 on 13 April was located about 125 miles south-southeast of Nantucket Island. It had deepened rapidly: central pressure was some 10 millibars lower than six hours earlier. Moderate rain was falling over southern and central New England, while some snow mixed with rain was reported over central Massachusetts. About one hour later the Boston observer reported rain and snow mixed, which changed to all snow at 2130.

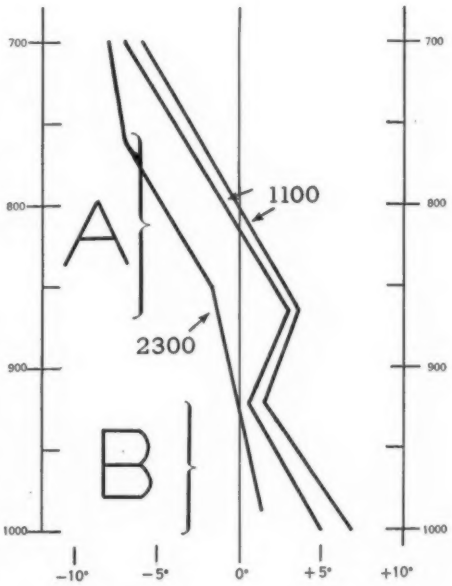
The rapidity with which the snow came is most intriguing. The temperature drop associated with the change to snow took place suddenly at Boston, where the dry bulb and dew point temperatures plunged from 43°/41° at 1832 to 33°/32° at 2130, a 10 degree drop in three hours.

How did this happen? The question forces us to examine some of the technical matters connected with the vertical temperature distribution over New England during the critical period, which is well illustrated by the upper-air sounding or raob for Portland, Maine, for 1100 and 2300 on 13 April, showing both before and after conditions with respect to the change to snow.

Following up the 1100 temperature line, we note, first, that a frontal inversion is present between 920 and 870 mb (2,600–4,400 feet) and, second, that the freezing level (0° C. isotherm) intersects the 1100 temperature line at about 800 mb (6,500 feet). The inversion belongs to the frontal system out in the Atlantic Ocean, which reaches back over New England as a sort of roof above the shallow layer of surface air that extends up to only 4,400 feet on the Portland raob.

Keeping the height of the freezing level in mind for immediate reference, we now inspect the 2300 vertical temperature pattern. We observe that it is everywhere on the left-hand, or colder, side of the 1100 sounding. Obviously, the atmosphere has cooled in the intervening 12 hours. We see that the cool-

The paths of the four lows that culminated in storm D, which gave Boston its late-season snowfall.



A composite upper-air sounding shows conditions at 1100 and 2300 EST, 13 April 1953, at Portland, Maine. The temperatures and dew points aloft for 1100 are plotted at the right, and the temperatures, only, for 2300, at the left. Area A extends from 8,000 feet to 4,400 feet, and Area B extends from 2,000 feet to the surface. Temperatures are in degrees Celsius, and heights are in millibars.

ing is most pronounced below about 8,000 feet. The freezing level now intersects the temperature line at 920 mb (2,600 feet). Since 1100, therefore, the freezing level has lowered almost 4,000 feet, and in only the bottom 2,600 feet of the air column are temperatures still above freezing. Finally, we notice that the dew point line crossed the 2300 temperature line in the neighborhood of 755 mb, indicating that beneath 8,000 feet the night air temperatures have fallen below the morning dew points.

The information derived from the soundings tell us that there are two possible explanations for the cooling of the lower atmosphere over New England and the related change from rain to snow at Boston.

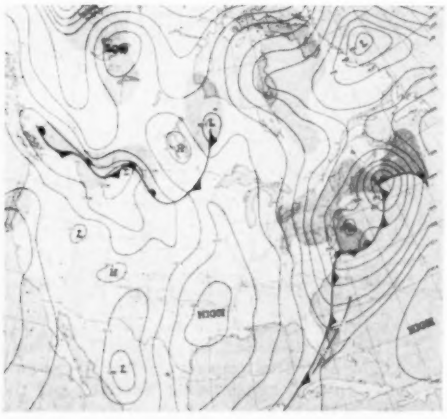
One explanation would be advection from a temperature minimum upstream, or, in less technical terms, the influx of colder air aloft. The other would be a locally-produced mechanism, which we will leave obscure for the moment.

Going back for a final look at the intricacies of the raobs, we cast an inquiring eye at the two areas between the lower parts of the two soundings. Area A extends from 8,000 feet down to 4,400 feet, that is, from the top of the layer of pronounced cooling to the top of the 1100 frontal inversion. Area B includes the surface portion of the cooled layer.

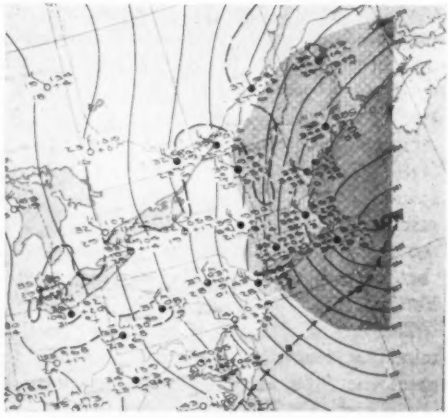
Let us now consider our cold advection explanation with the aid of the upper-air charts drawn for the 850 mb level which show the pressure contours and wind flow at approximately the 5,000 feet level. We gather from the similarity of the positions of the low center on both maps that the windstream over New England during the interval in which the sudden cooling took place was such as to produce a slight transport of northerly air into the Boston region and consequently a small amount of cold air advection. So this factor may account for a good part of the temperature decrease in Area A.

So far, so good. Now to Area B. Disconcertingly, our promising cold advection theory breaks down when applied to the cooling of the lowest 2,000 feet. The current weather map reveals that the gradient wind flow was coming from the northeast about an hour before the rain became mixed with snow at Boston. This direction, in the prevailing synoptic situation, can produce practically no advective temperature change.

The possible effect of an advective factor working in Area B can be further explored by comparing the time of the change to snow at Boston with the times at surrounding stations. If cold air advection in the lowest layer were the main cause of the change in the character of the precipitation, we should expect to find that the snow started upstream earlier than it did at Bos-



The North American weather map for 1330 EST, 13 April 1953, indicates the location of storms C & D off the New England coast. USWB map.



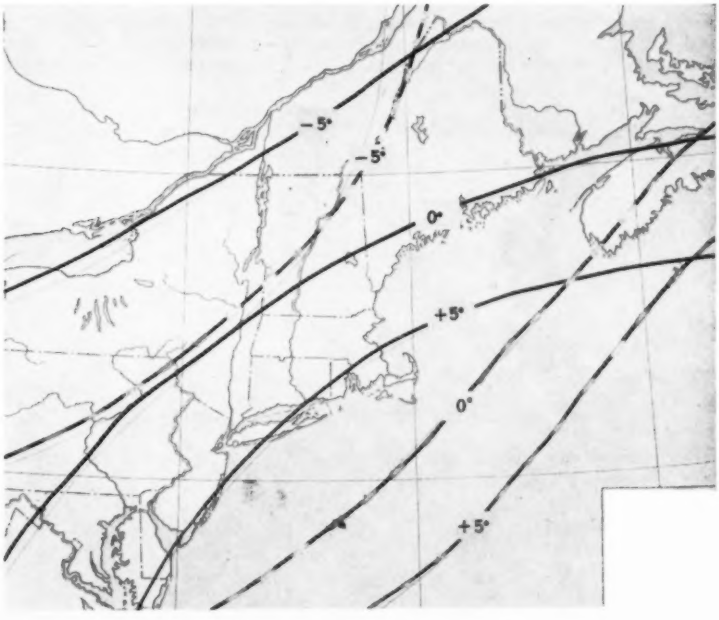
The sectional weather map for 0130 EST, 14 April 1953, shows storm D with snow falling on the central New England coast and rain prevailing both to the north and south. USWB map.

ton. Observations, however, prove contrariwise. For instance, all snow was reported from Boston at 2130, but not until 2330 at Portland, Maine, about midnight at Lebanon, New Hampshire, and 0330 of the 14th at Concord, New Hampshire. The difference in time of the onset of the snow between Boston and Portland—which lies in the path of any low-level advection and hence was chosen for the raob consideration—is particularly significant.

So, it is time to try out our second possible explanation. It is, in brief, locally-induced cooling of the air over Boston and vicinity in the surface layer we called Area B. Here we are confronted by two possible mechanisms that may effect such cooling. The first can be dismissed rather shortly, since it is not an important operative factor in our situation. Local cooling brought about by adiabatic ascent of air would be almost *nil* because of the saturated condition of, and moist adiabatic lapse rate existing in, the lower atmosphere about the time of the change to snow.

Local cooling, however, may also originate because of an exchange of heat between the air beneath the freezing level and the snow falling into this layer from above. On the evening of 13 April, precipitation above 7,000 feet or so was most likely in the form of snow. Melting of snow—to give rain at the surface—extracted a quantity of heat from the above-freezing lowest layer as the snowflakes passed through it. In other words, the melting process initiated local and relatively low-level cooling. Heat is needed to raise the temperature of the snow up to zero Celsius, and an additional 80 calories is required for the conversion of each gram of snow into the liquid state. Obviously, an increase in the rate of precipitation will increase the rate of cooling; or, stated another way, the cooling will be more rapid where the precipitation rate is greater. When there is no warm air advection in the layer concerned—and there was none in the 13 April case—to offset the type of cooling just described, a heavy rainfall can produce in a few hours a pronounced reduction in air temperature. It appears meaningful that the largest 6-hourly precipitation for the period ending at 0130 14 April was reported from Boston.

Our surprise snowstorm, then, may be explained on the basis of combined local and advective cooling as outlined above. Local cooling due to heavy rainfall appears to have been the major cause of the temperature fall in the lowest layer of air, with advective cooling operative around 5,000 feet. Their joint agency resulted in the change from rain to snow in and around Boston. Whether or not Bostonians realize the interesting complexities of the case, which this account has attempted to clarify, they at any rate will long remember their April 1953 freak snowstorm.



The chart demonstrates the change in location of isotherms at the 850 mb level (5,000 feet) for 1100 and 2300 EST, 13 April 1953. Solid lines are readings at 1100 and broken lines, at 2300. Temperatures are Celsius.

Weatherwatch

A Late Spring Follows a Mild Winter

DAVID M. LUDLUM, *Editor*

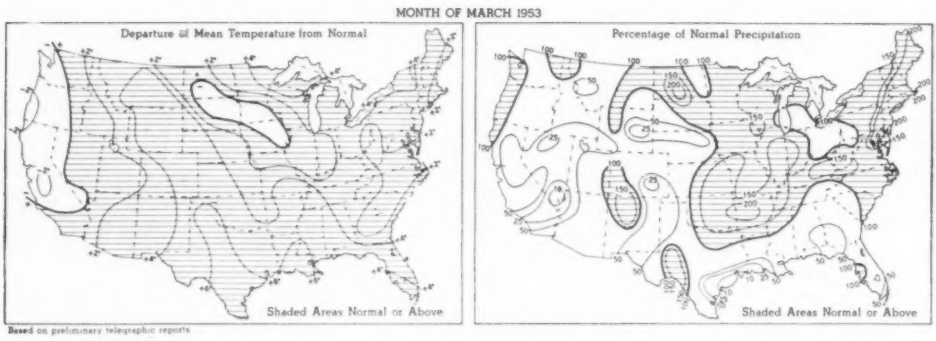
THE winter of 1952–53 was the second warmest in the past 60 years when considered on a nationwide basis. The circulation features that brought about this remarkable spell of mild conditions across the continent continued to hold sway through the month of March, and all sections except the immediate Pacific Coast enjoyed continued above normal temperatures. In the extreme West the circulation continued in March to bring maritime air over the land, but the water was relatively colder than the land, so the same circulation that brought above normal readings during the winter months caused slightly below normal readings in early spring. The varied seasonal effects of the same type of circulation has been pointed out to WEATHERWISE by William Klein of the Extended Forecast Section, U. S. Weather Bureau.

The main ingredients of the remarkably persistent December through March circulation were: (1) a strong flow of west and west-southwest winds across the breadth of the Pacific Ocean that brought vast quantities of mild maritime air to all points of the United States. (2) a southerly component of the circulation was marked over Canada as a low pressure belt extended from the Aleutian low off Alaska across the North American landmass to another mean low pressure center in northeastern Canada; this permitted maritime air to penetrate from both the Pacific and Atlantic into the sub-Arctic and contained polar and arctic air masses generally to the Arctic itself. (3) a blocking high existed in the central Atlantic Ocean, forcing lows to move northward over the central and eastern United States and inducing a southeasterly flow of maritime air over the continent to give mild but wet weather along the Atlantic seaboard.

Circulation patterns have varying periods of persistence, though generally they appear to extend from about six to ten weeks in their life span. It has been pointed out by Jerome Namias that the major circulation breaks seem to come in the October–November and the March–April periods, and this year followed the rule. One will recall the extremely cold weather in the East during October 1952 and in the West during November. Following these two preludes to winter came a shift in the circulation to maritime control that brought our remarkably mild winter, which was discussed in WEATHERWISE, April 1953, p. 54.

The first signs of a change in the circulation this spring became apparent during the very last days of March when a trough of low pressure moved eastward to a position off the Pacific Coast, and by 3 April had developed a low center off southern California with a trough extending northwestward. At the same time a ridge of high pressure began building northeastward from the main Pacific high, and marked pressure rises took place in Alaska. In the Atlantic Ocean, too, there were new developments; the blocking high that had held position most of the winter extended an arm northwestward toward Greenland and northeastern Canada. Anticyclonic activity became dominant in the Arctic. A large high, 1050mb-31.00", appeared on the weather map for 10 April in the Mackenzie-Yukon area. The Canadian Arctic once again became a cold air source for the United States.

Several deep lows developed in the trough now over the Southwest and followed tracks northeastward across the central part of the country to Quebec where another mean low pressure area was a feature of the April upper-air map. The Quebec


MONTH OF MARCH 1953
Departure of Mean Temperature from Normal
Shaded Areas Normal or Above
Based on preliminary telegraphic reports
Percentage of Normal Precipitation
Shaded Areas Normal or Above

Departure of mean temperature from normal in degrees F., March 1953. USWB chart.

Percentage of normal precipitation, March 1953. USWB chart.

low served as a pinwheel action to bring polar air southward behind the tracks of the lows traversing the Mississippi Valley or their secondaries moving up the Atlantic Coast. The regime of a western ridge-central trough-eastern ridge is a cold weather type for the Middle West; it was there and in the Great Plains that the greatest April temperature departures took place. Along the immediate Pacific Coast April temperatures were just about normal, but from the Coastal Ranges eastward to the crest of the Appalachian Mountains in the Northeast and to the coast in the Southeast the polar front held sway with repeated incursions of cold air. The persistence of warm weather in the extreme Northeast may be explained by the southeasterly flow into the Quebec low. Another warm area appeared in the Rio Grande Valley of Texas where the circulation was off the Mexican desert, and a serious drought condition intensified during the spring.

A WET SPRING IN THE NORTHEAST—Precipitation was far above normal in the Middle Atlantic and New England states during the first four months of 1953 with averages of 140 per cent and 158 per cent, respectively, of the normal. At Boston all previous records were shattered for the four-months' period, and at New York it was the second wettest first one-third of the year. March was the period of heaviest falls, and the following stations reported the highest state totals for March:

Wolcott Reservoir, Conn.	15.86
Pinkham Notch, N. H.	13.43
North Bridgeton, Me.	12.03
Boston, Mass.	11.69
White Plains, N. Y.	11.44
Mays Mill, Vt.	11.34
Austin, R. I.	10.62
Paterson, N. J.	10.35

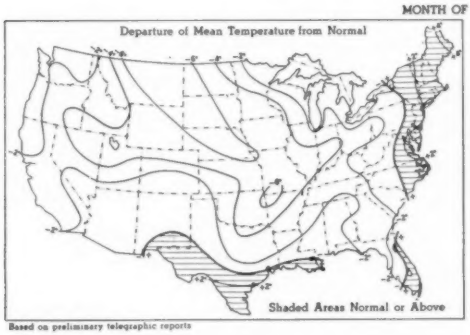
There are two periods of excessive rainfall over the area. On 12–13 March most of the Middle Atlantic area received over two inches from a secondary which developed out of a complex low system over North Carolina. New York City measured 3.05 inches in 24 hours on the 12–13th, and the belt of heavy precipitation extended northeastward to southern Maine. Temperatures in New England during the storm were generally in the low forties. One cannot miss noticing the coincidence of dates of this storm with the great Blizzard of 1888, when about the same quantity of moisture was deposited on southern New England, but it was in the form of snow then. Some flooding resulted from the mid-March rains in the suburbs of New York City.

The second period of excessive rains came on 25–31 March. In a survey of this period James McGuire and Samuel Penn of the Boston Weather Bureau point out that the centers of heaviest rain from 24–28 March moved northeastward from Virginia to Maine, while the intense rains of 29–31 March were confined mainly to the coastal area of New England. At Boston a 24-hour March record was broken with a new mark of 3.09 inches set on 30 March.

Floods developed in central New Hampshire and southern and central Maine, mainly along the watersheds of the Saco and Androscoggin rivers where major floods were experienced. In Maine, where the total rainfall exceeded that of the disastrous March 1936, the resultant floods were not as severe, there being little snow cover and the rivers being unfrozen. Mr. E. W. G. Klieman of the Portland Weather Bureau has summarized the flood damage: "The State estimated that $500,000 damage was caused to state-owned roads and bridges and an equal amount to town-owned roads and bridges. And it is estimated that $9 million damage was caused, mostly by silt and by work stoppage and ruined furniture. The total estimate of flood damage is therefore $10 million."

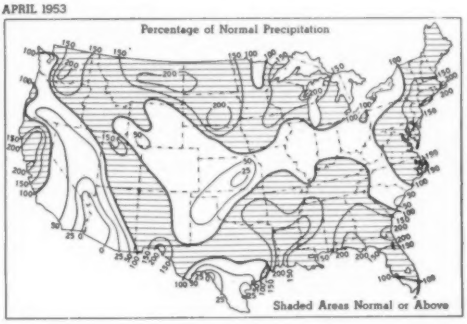
APRIL COLD SPELLS—The change in circulation from the winter type to that which prevailed throughout the month of April first had its effect in the Pacific states. Following the passage of a long north-south cold front on 30 March, the Pacific high pushed inland over British Columbia and Washington and dropped the nighttime temperatures to levels that had not been experienced since last November. Frost damage was heavy in

MONTH OF APRIL 1953



Based on preliminary telegraphic reports

Departure of mean temperature from normal in degrees F., April 1953. USWB chart.



Percentage of normal precipitation, April 1953. USWB chart.

the states of Washington, Oregon and Idaho. A second surge of cold air on 6–7 April penetrated the entire West and brought a major freeze in most areas. The mercury at Winnemucca, Nevada, plunged to 9° on the 8th, a new April record, and in Utah up to 24 inches of snow fell at the eastern edge of the Great Salt Lake Valley in Utah. In the Northwest further damage from frost resulted, and early fruit, especially apricots and cherries, were killed in some areas.

In the Napa Valley of California the mercury fell below 30°, the critical point, for over four hours, and the first major freeze since 1936 chilled the area that was already about two weeks ahead of schedule due to the warm winter and early spring. In the lower San Joaquin Valley the readings touched 32° at Fresno, a new April minimum, and damage to crops was termed "very severe." The freeze reached the Los Angeles area where the Ojai district had frost damage on the 8–9th, and close to San Diego frost withering was reported from the Julian district.

The center of the cold weather moved eastward as the reservoir of cold air in the great Canadian anticyclone was enticed southeastward by a series of lows that formed in the Southwest and took easterly courses, bringing the polar front into the South. Along the eastern border of the Rockies, Denver had an intense April snowstorm, the mercury dropped to 10° at Goodland, Kansas, on the 12th, and the freezing line extended into the Texas Panhandle.

The week ending 20 April was the coldest mid-April week on record in North Dakota with averages as much as 15 degrees below normal: an extreme low of 0° was reported at Belcourt on 17 April. Further east the cold surge brought low readings in the Ohio Valley and the Southeast, in many areas the lowest ever observed for so late in the season. Freezing reached as far south as Augusta, Georgia, and Columbia, South Carolina. In the Northeast there were several periods of snow: central New England had up to eight inches on the 12–13th, Montpelier, Vermont, again had eight inches on the 20th, and Cleveland, Ohio, reported a wet fall of five inches one day earlier. Though unusual, these falls were by no means records when compared to the 36 inches that fell in Pennsylvania on 27–28 April 1928 or the 35 inches in New Hampshire on 13–14 April 1933.

TORNADOES—Late winter and spring have been marked by widespread tornado activity. This may be largely explained by the frequent presence of the polar front in central and southern United States, bringing tropical and polar air masses into active contact. The wide geographical distribution was illustrated by the three most destructive storms, all of which hit built-up industrial areas with heavy loss of life: Warner Robbins, Georgia 30 April; Waco, Texas, 11 May; and Port Huron, Michigan-Sarnia, Ontario, 21 May.

WEATHER MODIFICATION

The Council of the American Meteorological Society has continued to keep in close touch with the development of knowledge in the field of weather modification and control. Although the scientific background is still far from complete the Council, as a public service, submits the following statements as a summary of present knowledge of weather modification and control. They amplify and extend the similar statements issued by the Council on 15 August 1951.

1. The seeding of a supercooled cloud with dry ice will usually convert at least a portion of the cloud to ice crystals. Under appropriate conditions such seeding will release variable amounts of precipitation from fairly deep and active cumulus clouds. Small, inactive cumulus clouds are usually dissipated when they are seeded with dry ice. Holes or valleys may be produced in supercooled layer clouds or supercooled fogs by seeding them with dry ice.

2. The injection of small water drops or salt particles into the bases of deep, warm (non-supercooled) cumulus clouds will usually release variable amounts of rain if the vertical velocities in the clouds are substantial. Small, inactive, warm cumulus clouds may often be partially or completely dissipated by seeding them from above with certain materials; such dissipation may be accompanied by rain of extremely light intensity.

3. In some cases warm fog or warm stratus may be dissipated in restricted regions by heat or by certain seeding agents other than dry ice or silver iodide.

4. It is known that silver iodide crystals will convert supercooled clouds to ice crystals at temperatures below about $-5°$ C. It is therefore reasonable to expect that precipitation might be released from supercooled clouds by silver iodide seeding. Experimental evidence of positive results from silver iodide seeding is not yet as convincing as the results of dry ice seeding. Among the possible reasons for poorer results with silver iodide are the lower temperature required, the effect of sunlight on the silver iodide and some uncertainty as to the infection of the proper region of the cloud.

5. Cloud seeding acts only to trigger the release of precipitation from existing clouds. The release of substantial amounts of precipitation by either natural or artificial means requires the pre-existence of an extensive moisture supply in the form of moist air currents and of active cloud-forming processes. For this reason the meteorological conditions most favorable for the artificial release of precipitation are very much the same as those which usually lead to the natural release of precipitation. This makes the evaluation of the effects of seeding difficult and often inconclusive.

6. Statistical analyses, by independent agencies, have failed to show that the monthly or seasonal precipitation over a selected target area has been significantly increased by ground-based silver iodide seeding. Although these studies do not preclude the possibility that the precipitation can be in-

(*Continued on page 86*)

CLOUD PHOTOGRAPHY PROJECT

(*Continued from page 73*)

of the world. Consequently most of the photographic effort during the next few years will be conducted in the United States and its possessions. Two or three cameras will be available for use in other parts of the world, however. At the present time one of these, after having been used for several months by F. H. Ludlam in England, is now employed in Sweden by the Institute of Meteorology at Stockholm. A second camera is currently located at a new mountain observatory in Peru, while a third has been sent to the Bahama Islands. During the spring of 1953 a camera was operated in western Florida, another in southern Colorado, a third in western Montana, and a fourth in eastern New York.

Time-lapse cloud photographs from 13 types of physiographic situations are planned during the next few years. These general areas are shown on the accompanying map. Co-operation from individuals or groups in these or similar areas who may be interested in furthering this cloud survey project would be gratefully received.

The current program in cloud photography is part of a series of projects sponsored by the Munitalp Foundation, Inc. A cloud survey in region No. 1 of the National Forest designed to establish the location of cloud breeding sites, lightning storm formation, storm tracks, and jet-stream clouds will be inaugurated in late June 1953 under the dual directorship of Mr. Jack Barrows of the U.S. Forest Service and the writer. Six movie cameras will be utilized on 25 mountain tops in an interlocked network; three of the cameras will be used to photograph a single local storm by using a triangular net.

Another project concerns a study of clouds formed in a jet stream, while a third will entail the building of a mobile observatory at the Department of Meteorology, University of Washington, under the direction of Prof. P. E. Church, the unit to be equipped with standard as well as new instruments for measuring many properties of the atmosphere. The development of these projects and results will be described in future issues of WEATHERWISE.

Physiographic areas for time-lapse motion picture studies of cloud formations:

A Isolated mountains	E Desert areas	I Maritime areas
B Mountain ridges	F Great Plains	J Coastal fogs
C Isolated mountain regions	G Great Lakes	K Wind gaps
D Inner mountain regions	H Eastern coastal plain	

Understanding the Weather. A revision of Knowing the Weather. T. MORRIS LONGSTRETH. The Macmillan Company, 1953. 118 pp. 13 cloud photos. $2.50.

This is a book by a long experienced, well-read, amateur meteorologist. It is nearly 40 years since Mr. Longstreth's *Reading the Weather* was published, and 10 years since *Knowing the Weather*. Though called a "revision" of the latter, it is really a new book and up-to-date in that the author took the trouble to study the great *Compendium of Meteorology*, published by the American Meteorological Society in 1951, and to digest for his readers the pertinent information contained therein. Though some parts may be somewhat abstruse, the author has been remarkably successful in presenting modern meteorology in terms a layman can readily understand. A philosophical turn here and there and a sprinkling of humor help. The dramatic qualities of the subject are not overlooked.

Our layered atmosphere, with emphasis on our growing realization of the importance of the higher layers with respect to our weather, is the subject of the first of 21 chapters. The large scale circulation, chapter two, outlines the increasing use of hemisphere-wide, and even world-wide circulations in modern forecasting. Air masses, the weather cradle, chapter three, however, brings us down to the particular. The mechanism of fronts is the subject of chapter five, while cyclones and anticyclones each have succeeding chapters. "An anticyclone is a safety island in the midst of cyclonic traffic." Wind, chapter eight, is naturally the next subject: "Wind is air on a mission—to reestablish the equilibrium of the atmosphere."

After showing that the United States has had an impressive range of 200 degrees in temperature, from −66° F. in Yellowstone Park, Montana, to +134° F. in Death Valley, California, it seems unfair of the author to attack the Fahrenheit scale in chapter nine. "The scientific world would have escaped a continuous and universal pain if Fahrenheit had chosen any other lifework than physics. . . . Only romantic English-speaking countries with a highly developed sense of nostalgia employ it." Now, really, Mr. Longstreth: we human beings think a scale, that gives 0° for blood-freezing cold and 100° for sizzling heat and 100 conveniently small divisions between, is just about right! The Weather Bureau continues to use Fahrenheit both because it is a popular scale and because of its real convenience. Seldom are there negative values to bother with, and the smallness of each degree usually obviates the need for dealing with fractions. It is really economical from the standpoint of time saved and printing costs.

The clouds, weather announcers, chapter 10, and fog, chapter 11, lead up to rain (old style) and prepare one for rain (man-induced), chapter 13, which is an excellent and entertaining summary of exciting experiments, claims, counter-claims, and possible ultimate possibilities of weather-control.

Chapters follow on snow, thunderstorms, hurricanes, and tornadoes. The remaining short chapters cover the applications of the weather: the weather map, forecasting, climate, and, finally, the amateur and his tools.

CHARLES F. BROOKS
Blue Hill Observatory

Weather Inference for Beginners. D. J. HOLLAND. Cambridge University Press, New York. 1953. 196 pages. $6.00.

"This book is for all who are interested in their daily weather," says the author in his introduction. The reviewer would like to add: for all, whether they reside in the British Isles or elsewhere, since the book has universal appeal for those who would like to understand the problems of predicting the weather. Mr. Holland has taken a unique and very effective method of presenting the intricacies of the behavior of highs and lows to aspiring forecasters. He has taken a series of local weather observations made as a schoolboy in 1936, and ten years later restudied and reinterpreted them with the benefit of the knowledge acquired in his professional work in the field. His audience, however, remains the amateur or the aspirant to a meteorological career, and the book will serve as an excellent introduction to physical meteorology whatever the type of fronts or air masses the reader may meet locally.

WEATHER MODIFICATION

creased they suggest that any increase has been relatively small.

7. Present knowledge of atmospheric processes offers no basis for the belief that the weather or climate of a large portion of the nation can be modified by cloud seeding. The results of experiments which have been conducted to explore such large-scale effects are considered to be inconclusive. Not all of the results are explainable in the light of present knowledge and further experimentation is desirable.

Amateur Weatherman's Almanac—1953

The Annual for all Weathermen

90 pages illustrated
all for one dollar

For your copy, send $1.00 now to:

WEATHERWISE,
Franklin Institute, Phila. 3, Pa.

A WEATHER STATION for AMATEURS

TEMPERATURE

No. 119 Maximum-minimum thermometer. Four inches in diameter. Easy reset. **$8.95**

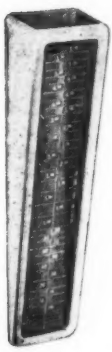
PRESSURE

No. 301 Baroguide. Reads to .10 inches. Dial five inches in diameter. **$10.00**

WIND

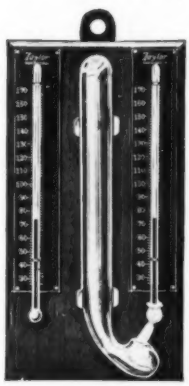
No. 410 Wind speed indicator. Direct reading type. Cups generate own power; no batteries. Complete with outdoor anemometer, small support, 50 feet of cable, and indoor indicator. **$49.95**

RAIN



No. 510 Direct reading gage fits on any fence post. Made of amber plastic with white graduations. Capacity six inches. Overall length 13 inches. Complete with bracket for mounting. **$4.95**

HUMIDITY



No. 201 Hygrometer, Mason type with fixed wet and dry bulbs. Water syphon reservoir. Range 30° to 120° F. With tables. **$7.50**

Send for
Complete Catalog

Science Associates

401 North Broad Street **Philadelphia 8, Pa.**

WHEN IT COMES TO WEATHER.....

BENDIX-FRIEZ

OFFERS THE RIGHT INSTRUMENT TO DO THE BEST JOB

FOR RECORDING TEMPERATURE, HUMIDITY

Hygro-Thermograph

The leader in its field. Noted for precise accuracy and long-time dependability. Portable, easy to operate. Widely used in laboratories, factories and offices.

Portable Temperature, Humidity Recorder

Rugged, compact design. Ideally suited for use in small space and difficult locations. Provides convenient 3 x 5 charts for 10 or 30 hour records.

FOR CHECKING BAROMETRIC PRESSURE

Microbarograph

A key meteorological instrument. Records atmospheric pressure to within .01 inch mercury. Record chart expanded 2½ times for greater visibility.

Aneroid Barometer

Inexpensive, dependable, easy-to-read. Shows pressure and barometric tendency. Housed in handsome brass case. Favored by professionals and amateurs alike.

FOR MEASURING WIND SPEED, DIRECTION

Aerovane*

Indicates and records wind speed and direction. Recognized as "best all-purpose wind measuring instrument yet devised." Readily installed and easily maintained.

Windial*

A fine precision instrument with large dials that show wind speed and direction at a glance. Popular with smaller airports, yacht clubs, schools, plants, etc.

*REG. U. S. PAT. OFF.

FRIEZ INSTRUMENT DIVISION of Bendix AVIATION CORPORATION

1316 TAYLOR AVENUE • BALTIMORE 4, MARYLAND

Export Sales: BENDIX INTERNATIONAL DIVISION, 72 Fifth Avenue, NEW YORK 11, N. Y.